X2000 Briefing

Introduction

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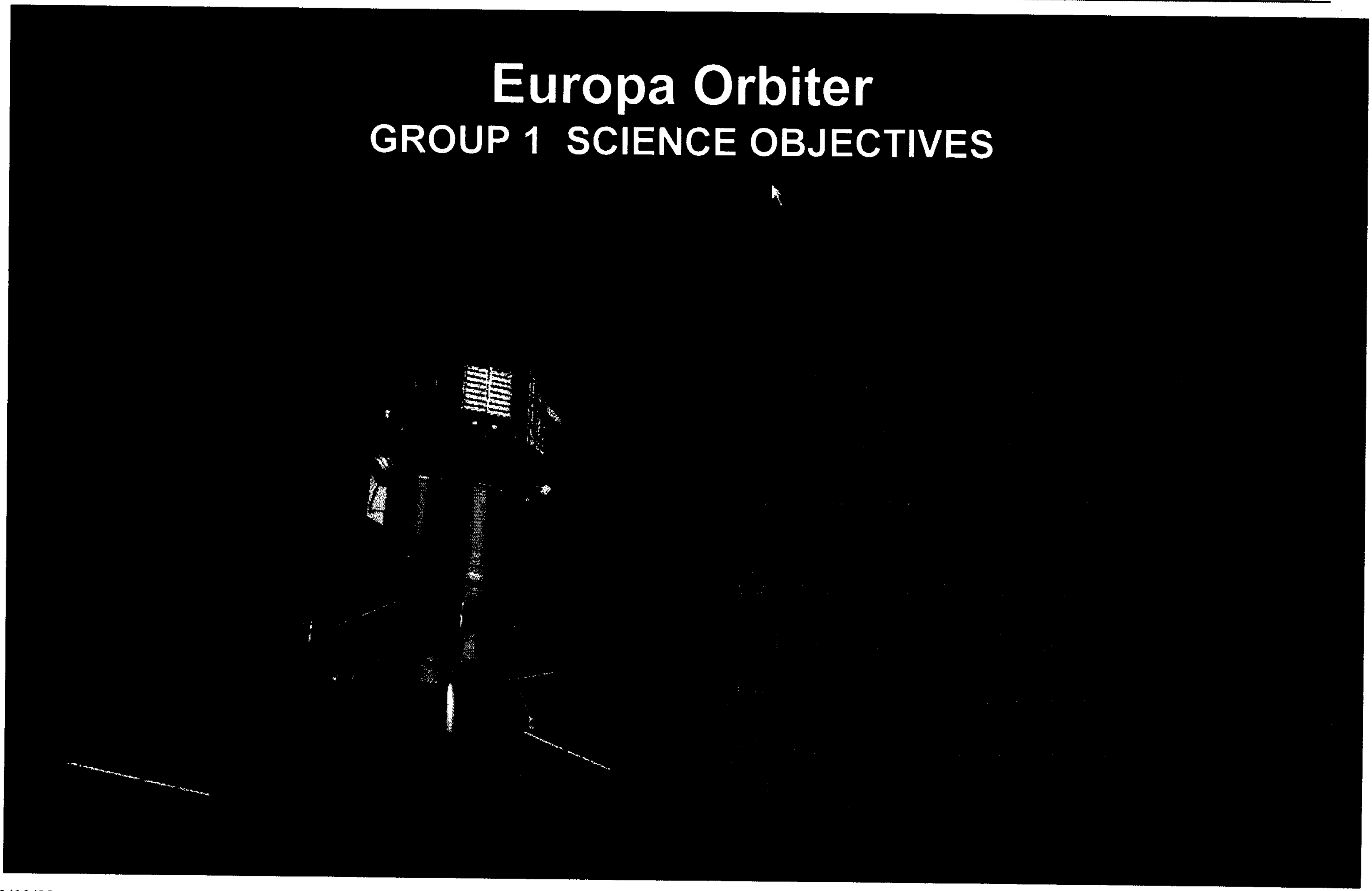
Science Objectives

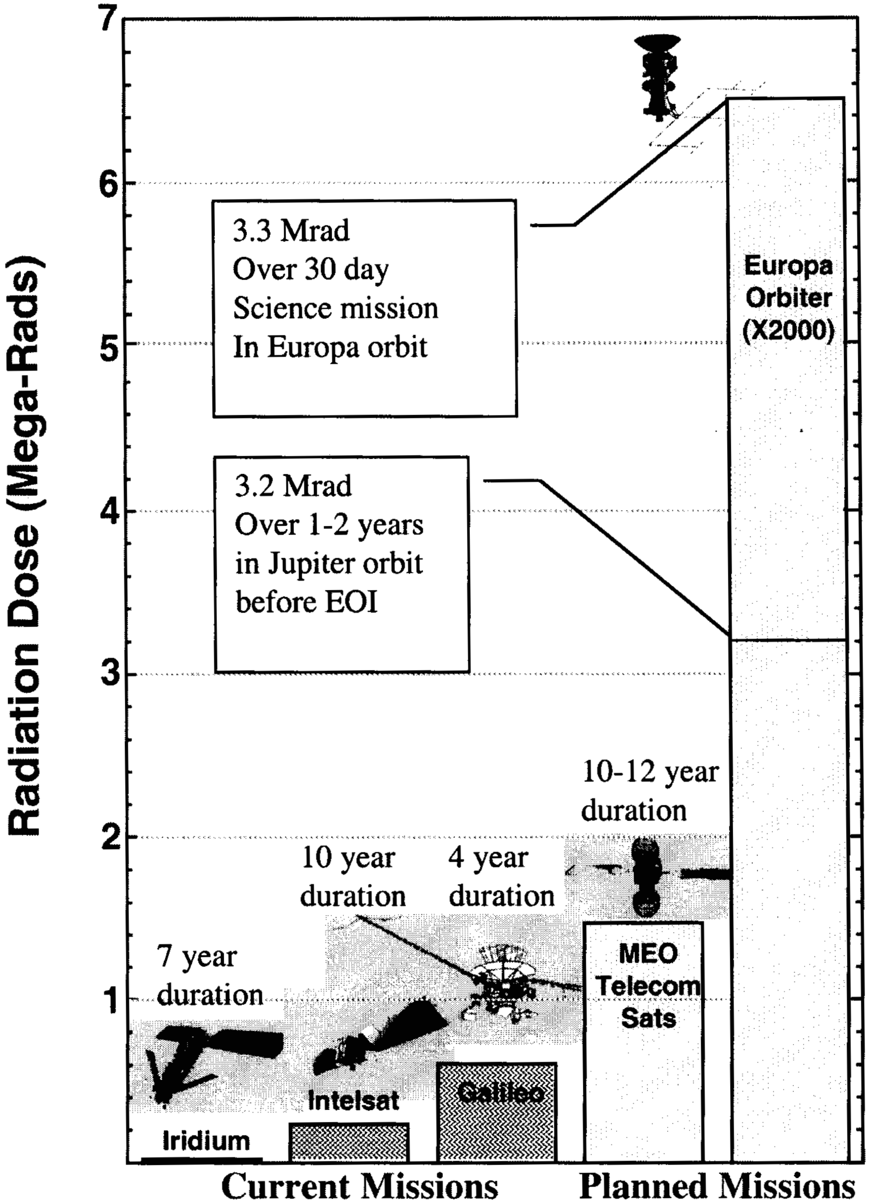


Three Characteristics

Three characteristics drive to cost and complexity of the Europa Orbiter Mission:

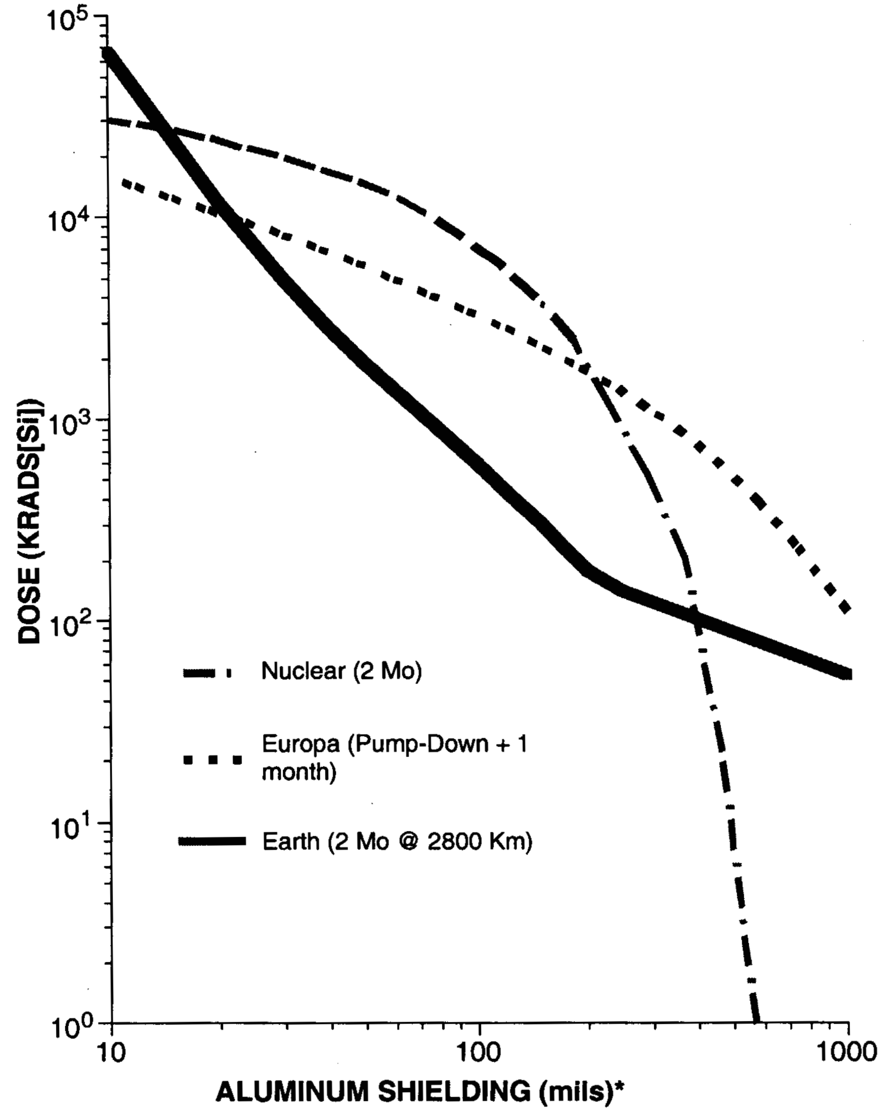
- Radiation Environment
- Radioisotope Power Source
- High Launch & Trajectory Energy Requirements

EO Mission Radiation Environment



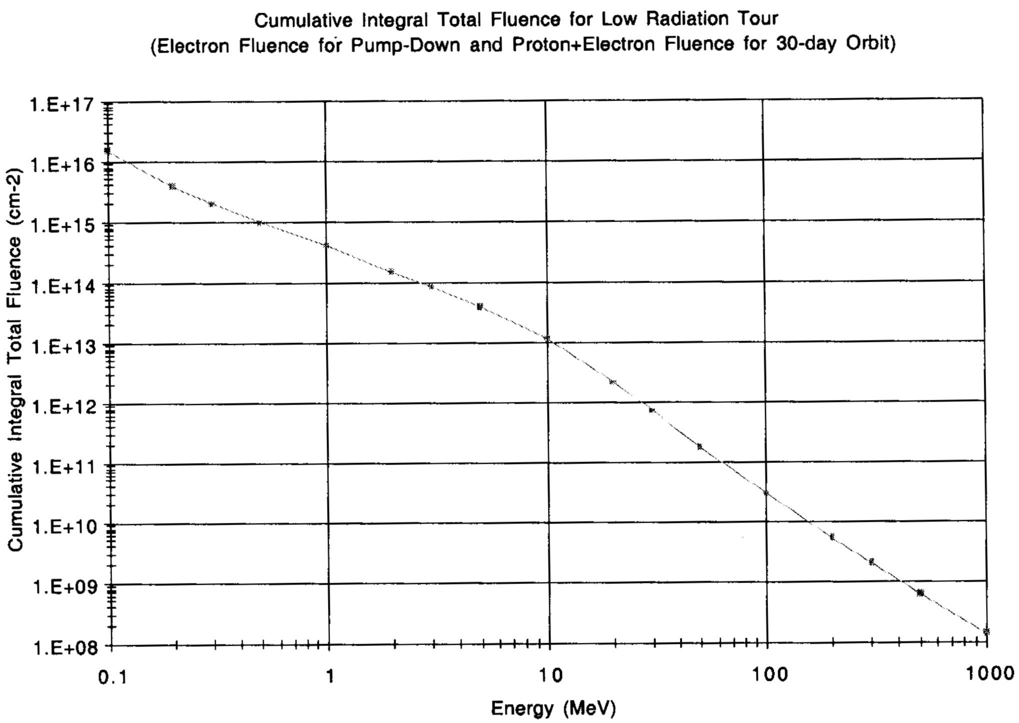
- The Europa Orbiter total dose environment is harsh compared to current experience
  - At Europa an astronaut inside an EVA suit receives a lethal dose every 12 minutes
- The Europa Orbiter must operate with high reliability during the 30 day mission
  - Science objectives
  - Achieve quarantine orbit
- Impact
  - High technology, high risk, high cost electronics development (X2000) to reduce risk
  - Total shielding = 39 kg

EUROPA AND EARTH RADIATION ENVIRONMENTS VERSUS SATURATED NUCLEAR ENVIRONMENT



*4π Spherical Shell

Radiation Fluence by Energy Level



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Europa Orbiter Mission
Radioisotope Power Source

- High development cost
  - $44M for Cassini heritage RTGs plus $32M Plutonium cost (DOE estimate)

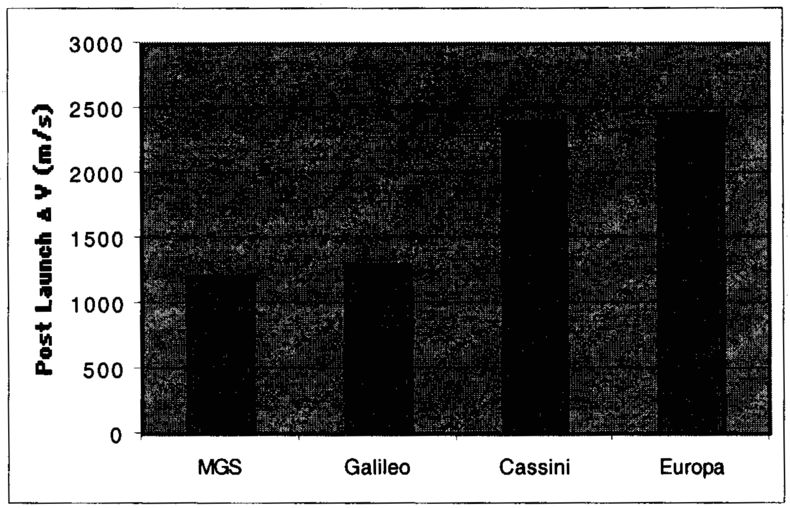
- EIS development and launch approval process
  - $12M minimum Europa cost over 6 year duration

- Flight termination system modification complexity and cost for use of solid rocket motor upper stage with radioisotopes (new requirement)
  - $15M mission unique cost held above core launch vehicle cost

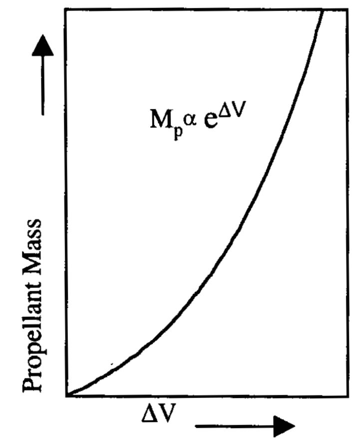
- High mass per watt produced
  - 56 kg per Cassini heritage RTG, 112kg total for Europa Orbiter
  - 5 watts/kg specific power for Cassini heritage RTG (~same for Stirling)

Europa Orbiter Mission
High Launch & Trajectory Energy Requirement

- Complex 1-2 year tour to reduce arrival energy (total direct to EOI would be ~6000 m/s; equivalent to Centaur - class stage at Europa)
- Large bi-propellant propulsion system to achieve JOI/EOI ΔV

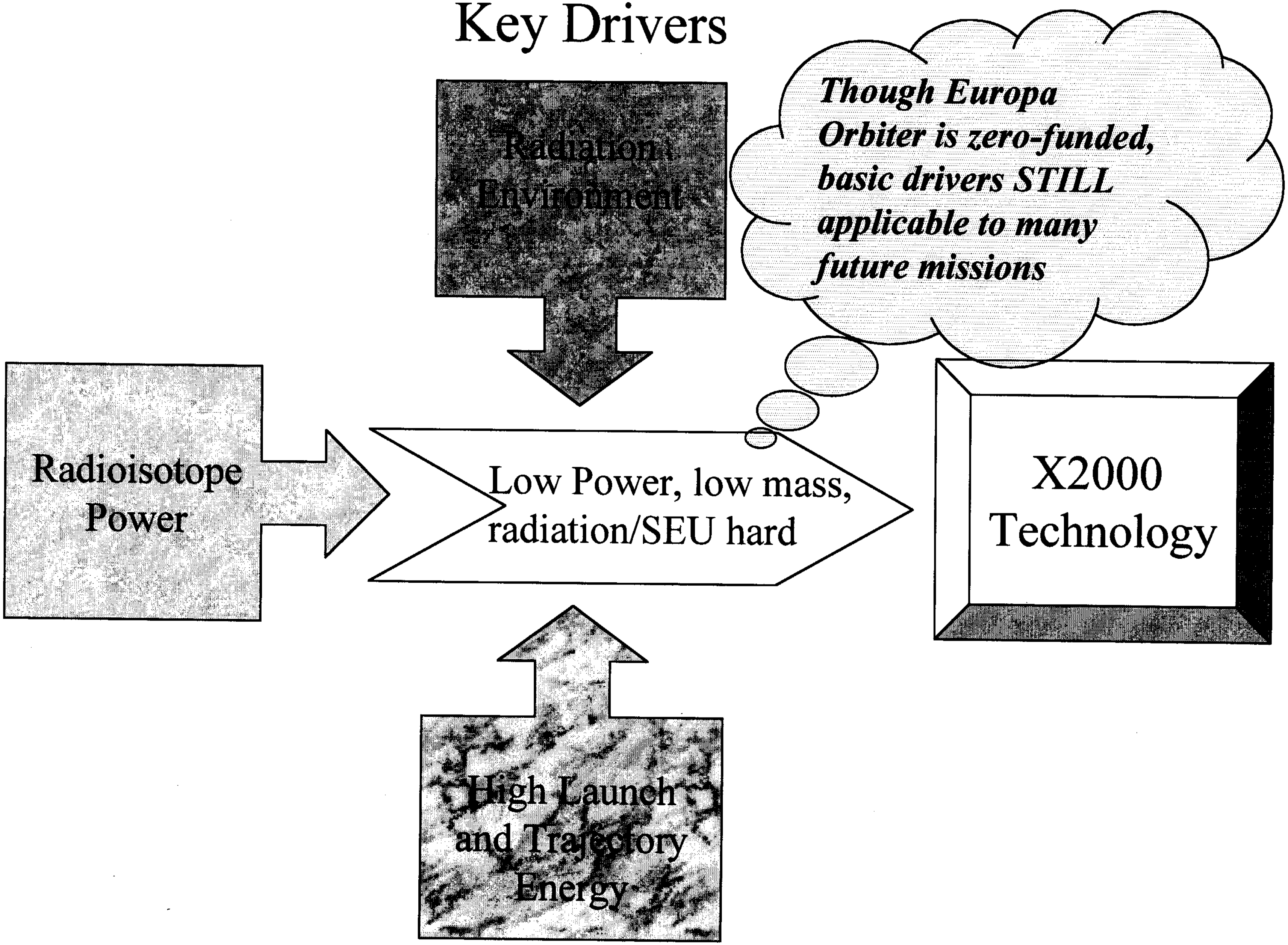


	Fully Fueled Europa Orbiter
Propellant:	1149 kg
Prop Dry:	149 kg
Total Propulsion	1298 kg
Total Launch	2100 kg



- Kick stage required for direct launches
  - Up to $25 M cost of development
  - Flight termination system modification cost reserve $15M
- High launch energy requirement for direct launches
  - Delta IV H

Key Drivers


Radiation Environment
Though Europa Orbiter is zero-funded, basic drivers STILL applicable to many future missions
Radioisotope Power
Low Power, low mass, radiation/SEU hard
X2000 Technology
High Launch and Trajectory Energy

X2000 Key Attributes

Performance Enhancements:

- Next generation spacecraft microprocessor technology – RAD750; 240 MIPS
- Dense 2 Gbit Non-Volatile Memory, low mass and power
- Fault tolerant tree topology using IEEE-1394a (Firewire) bus, 1000 Mbps
- Low power, fault tolerant I^2C serial bus, 100 kbps

Advantages:

- Increased/Improved On-Board Data Processing and Handling
- Increased on-board autonomy

Disadvantages:

- Non-Volatile Memory not Radiation Hardened – requires significant shielding
- Many Instruments and sensors not yet 1394a compatible

X2000 Key Attributes

Technology Pushes:

Honeywell HX3000 ASIC line – increased functionality, maximum speed 250 Mhz, 3.3 V, Radiation/SEU hardened (1 Mrad)

Honeywell HX2000 ASIC line – Increased functionality for Mixed Signal and Power ASICs, maximum speed 100Mhz, 3.3 V and 5 V, High voltage transistors, Radiation/SEU hardened (1 Mrad), Redundancy on single chip

BAE SYSTEMS Manassas ASIC line – 0.5 u, 3.3 V, Radiation/SEU hardened (1 Mrad)

U.S. Foundry ASIC Line – 0.25u 2.5V/3.3V (I/O), Radiation/SEU hardened line (200Krad)

Advantages:

Low voltage leads to lower power

Inherent radiation hardness allows less mass

Creating libraries of cells to benefit future designs

Learning "idiosyncrasies" of ASIC lines and physical limitations

Disadvantages:

Has been difficult characterizing line and stabilizing ASIC design processes

High voltage power circuit design on low voltage process introduces unknowns

Lower voltages introduce signal sensitivity issues

More SEU tolerant cells require increased power and layout area

X2000 Key Attributes

Compact, Modular, Scaleable:

compactPCI 3U form factor packaging approach

Smart power switching - Power Activation and Switching Module (PASM)

Advanced high efficiency power converter

Ball/Column Grid and High Density Interconnect Packaging

Expandable, multidrop busses

Advantages:

Decreases mass, volume

Allows flexibility in configuration

Disadvantages:

High development cost

New qualification

Technology limits circuit/functionality denseness

Rework limitations

X2000 Key Attributes

Ease of Implementation:

- Open architecture for advanced spacecraft systems based on commercial/ standardized electrical and mechanical interfaces
- Incorporates commercial IP into avionics system for space application

Advantages:

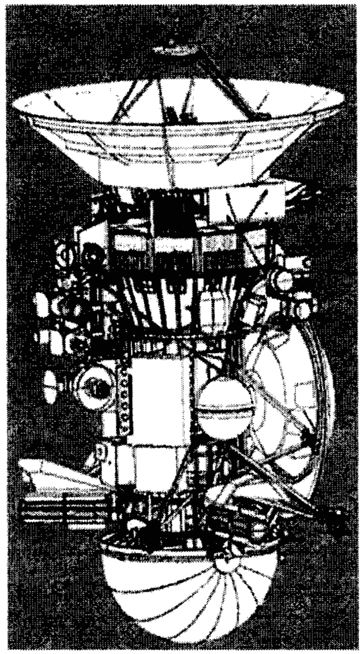
- Allows commercial test equipment and software
- Allows pre-tested interfaces prior to final integration
- Provides low-cost commercial testbed for early flight software development

Disadvantages:

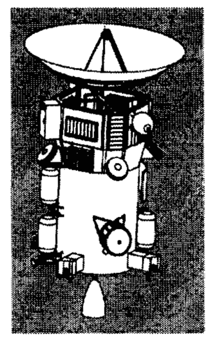
- Commercial IP not flight qualified, test benches not to level of rigor required for flight validation
- Propriety nature of Commercial IP does not allow for easy de-bugging of issues
- Commercial IP required significant fault protection enhancement

X2000: Contributions and Users

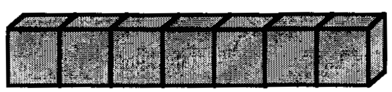
Cassini S/C
22.3 ft (6.7 m)



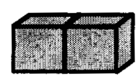
Europa Orbiter S/C
11.4 ft (3.5 m)



Cassini Bays



X2000 First Delivery Chassis



X2000 Users

JPL

- Europa Orbiter - Full Flight Set
- Deep Impact - Flight Computer/ Nonvolatile Memory/ System Interface ASIC
- ST-3 - Flight Computer/ Nonvolatile Memory/ System Interface ASIC
- Mars 07 - Considering Full Flight Set
- SIM - 8 Flight Computers baselined
- Technologies - Various new concepts that utilize the X2000 ASICs

GSFC/NOAA

- NPP (NPOESS Preparatory Project)/NPOESS - Flight Computer & 1394 bus baselined (SIO)

DOD

- SBIRS Low - Considering Avionics

Mass (kg)	170	43	Plus Shielding of 13kg for X2000 electronics only
Power (W)	137	167	at Orbit Insertion
Volume (m^3)	.252	.074	
Hardness (krads)	350	5000	
Processing Speed (MIPS)	1	60-200	Effective (240 MIPS Dhrystone)

Next Steps

- Current X2000 development schedule is based on previous Europa Orbiter schedule and funding profile
- Europa Orbiter was Zero-funded in President's Budget Submittal (released 2/4/02) for 2003 and beyond
- X2000 development was fully funded in same budget for completion in 2005
- X2000 development will be re-planned over next few months to fit within latest funding profile
  - Some milestones are expected to move forward
  - Scope expected to remain the same